



TRANSACTIONS, AMERICAN GEOPHYSICAL UNION
VOLUME 62, NUMBER 41, OCTOBER 13, 1981

EOS

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOL. 62, NO. 41, PAGES 697-704

OCTOBER 13, 1981

Tectonophysics

5170 Plate tectonics: THE SUBDUCTION OF THE EASTERN PANAMA BASIN AND THE RECONSTRUCTION OF NORTH-AMERICAN SOUTH AMERICA.
A. Pennington (Department of Geological Sciences, The University of Texas at Austin, Austin, Texas 78712).
Spreading along the Caribbean-Nazca plate boundary since the breakup of the Farallon plate in the Miocene has resulted in the formation of the Panama Basin and a complex interaction of plates in and near northern South America. Current plate boundaries have been defined, and segments of subducted lithosphere identified through selection of hypocentral locations of earthquakes, considering only well-located events, and through focal mechanism determinations. The existence of tectonic plate boundaries, bathymetric features, and the Panamanian orogenic belt have been determined. The subduction process of the Nazca plate beneath South America and determined the present-day configuration of the subducting lithospheric plate.

There is no single triple junction separating the Caribbean, South American, and Nazca plates. They are accommodating east-west compression (and a lesser degree of north-south compression) along a series of thrust faults striking NNE to NE, and the Andean ranges of Ecuador, Colombia, and Venezuela are moving as a block NNE relative to the rest of the South American plate, along a system of faults following the front of the Eastern Cordillera.

The subducted portions of the Panama Basin and old Farallon plate have become segregated into three parts: (1) a "Bocananga" segment continuous with the Caribbean sea floor northeast of Colombia; (2) a "Cura" segment continuous with oceanic crust (Nazca plate) currently being subducted beneath South America at the Colombia-Ecuador trench; and (3) an "Ecuador" segment at the northern end of the subducting lithospheric plate which is dipping at a small angle to the east beneath northern Peru. The segmentation of the subducted plate can be explained by the buoyancy of bathymetric features which have been partially subducted.

J. Geophys. Res., Vol. 86, Paper 18127

5170 Plate tectonics: THE SUBDUCTION OF THE EASTERN PANAMA BASIN AND THE RECONSTRUCTION OF NORTH-AMERICAN SOUTH AMERICA.
A. Pennington (Department of Geological Sciences, The University of Texas at Austin, Austin, Texas 78712).
Spreading along the Caribbean-Nazca plate boundary since the breakup of the Farallon plate in the Miocene has resulted in the formation of the Panama Basin and a complex interaction of plates in and near northern South America. Current plate boundaries have been defined, and segments of subducted lithosphere identified through selection of hypocentral locations of earthquakes, considering only well-located events, and through focal mechanism determinations. The existence of tectonic plate boundaries, bathymetric features, and the Panamanian orogenic belt have been determined. The subduction process of the Nazca plate beneath South America and determined the present-day configuration of the subducting lithospheric plate.

There is no single triple junction separating the Caribbean, South American, and Nazca plates. They are accommodating east-west compression (and a lesser degree of north-south compression) along a series of thrust faults striking NNE to NE, and the Andean ranges of Ecuador, Colombia, and Venezuela are moving as a block NNE relative to the rest of the South American plate, along a system of faults following the front of the Eastern Cordillera.

The subducted portions of the Panama Basin and old Farallon plate have become segregated into three

parts recognized in this study. From north to south, they are: (1) a "Bocananga" segment continuous with the Caribbean sea floor northeast of Colombia; (2) a "Cura" segment continuous with oceanic crust (Nazca plate) currently being subducted beneath South America at the Colombia-Ecuador trench; and (3) an "Ecuador" segment at the northern end of the subducting lithospheric plate which is dipping at a small angle to the east beneath northern Peru. The segmentation of the subducted plate can be explained by the buoyancy of bathymetric features which have been partially subducted.

J. Geophys. Res., Vol. 86, Paper 18127

5170 Plate tectonics: THE SUBDUCTION OF THE EASTERN PANAMA BASIN AND THE RECONSTRUCTION OF NORTH-AMERICAN SOUTH AMERICA.
A. Pennington (Department of Geological Sciences, The University of Texas at Austin, Austin, Texas 78712).
Spreading along the Caribbean-Nazca plate boundary since the breakup of the Farallon plate in the Miocene has resulted in the formation of the Panama Basin and a complex interaction of plates in and near northern South America. Current plate boundaries have been defined, and segments of subducted lithosphere identified through selection of hypocentral locations of earthquakes, considering only well-located events, and through focal mechanism determinations. The existence of tectonic plate boundaries, bathymetric features, and the Panamanian orogenic belt have been determined. The subduction process of the Nazca plate beneath South America and determined the present-day configuration of the subducting lithospheric plate.

There is no single triple junction separating the Caribbean, South American, and Nazca plates. They are accommodating east-west compression (and a lesser degree of north-south compression) along a series of thrust faults striking NNE to NE, and the Andean ranges of Ecuador, Colombia, and Venezuela are moving as a block NNE relative to the rest of the South American plate, along a system of faults following the front of the Eastern Cordillera.

The subducted portions of the Panama Basin and old Farallon plate have become segregated into three

parts recognized in this study. From north to south, they are: (1) a "Bocananga" segment continuous with the Caribbean sea floor northeast of Colombia; (2) a "Cura" segment continuous with oceanic crust (Nazca plate) currently being subducted beneath South America at the Colombia-Ecuador trench; and (3) an "Ecuador" segment at the northern end of the subducting lithospheric plate which is dipping at a small angle to the east beneath northern Peru. The segmentation of the subducted plate can be explained by the buoyancy of bathymetric features which have been partially subducted.

J. Geophys. Res., Vol. 86, Paper 18127

of activity is observed. The concentration of earthquakes in the 10-50 km depth range in a limited region beneath the Taimur-Nagu Ridge suggests that convergence between the two plates is proceeding by shortening within the basin of the intervening Molucca Sea plate rather than by slip along shallow thrusting planes between the arcs and the subducted slab. Published focal mechanism solutions suggest that high-angle reverse faulting beneath the Taimur-Nagu Ridge generates almost all of the seismic energy release within the collision zone. The predominance of shallow reverse and strike-slip faulting at the axis of the bilaterally subducting Molucca Sea lithosphere suggests that stresses are not due to bending alone and have a large horizontal component perpendicular to the island-arc geometry and state of stress within the Molucca Sea lithosphere require an external driving force for convergence between the two arcs and a strong degree of coupling between the island-arc and the subducting Molucca Sea plate; at least at the present stage of collision.

J. Geophys. Res., Vol. 86, Paper 18142

5170 Structure of the lithosphere: AN ANALYSIS OF GEOD AND GEODYNAMIC DATA FROM THE HINDUCOCHIN PLATEAU.
R. S. Detrick, Jr. (Graduate School of Oceanography, Univ. of Rhode Island, Kingston, RI 02881).
Should the thickness of the lithosphere be constant across oceanic fracture zones due to the juxtaposition of lithosphere with different ages and positions of lithosphere with different ages and positions of lithosphere? At a ridge-transform intersection, the total geoid offset depends on the age difference across the fault and is expected to be proportional to the age offset. The amplitude and shape of this anomaly will change along the length of a fracture zone depending on how the lithosphere cool. If the lithosphere thickens indefinitely (boundary layer model), then the geoid offset will remain constant across the width of the transition zone from one side of the fracture zone to the other. If the geoid offset is to both heat transfer across the fault and an increase in the average depth of compensation, it, however, the lithosphere eventually approaches a constant thickness (plate model), the geoid offset will decrease with distance from the fracture zone. An analysis of eighteen GEOD altimetry profiles across the Hinducochin fracture zone (offset 25-30 m.y.) indicates that the geoid amplitude systematically decreases from one side of the fracture zone to the other. The fracture zone seems to behave as a single continuous (older) part of the fault. Although the geoid offsets across the older portion of the fracture zone seem to show one meter across the transition zone, this large decrease in geoid offset strongly suggests that the lithosphere is not a constant thickness along the entire part of the fracture zone. A plate thickness of 100 km fits the observed change in geoid offset along the Hinducochin, but the age differences in the offset determination, the age of the fracture zone, and the age of the plate and the age of the fracture zone, this probably represents a minimum estimate of total plate thickness.

J. Geophys. Res., Vol. 86, Paper 18142

5170 Structure of the lithosphere: AN ANALYSIS OF GEOD AND GEODYNAMIC DATA FROM THE HINDUCOCHIN PLATEAU.
R. S. Detrick, Jr. (Graduate School of Oceanography, Univ. of Rhode Island, Kingston, RI 02881).
Should the thickness of the lithosphere be constant across oceanic fracture zones due to the juxtaposition of lithosphere with different ages and positions of lithosphere? At a ridge-transform intersection, the total geoid offset depends on the age difference across the fault and is expected to be proportional to the age offset. The amplitude and shape of this anomaly will change along the length of a fracture zone depending on how the lithosphere cool. If the lithosphere thickens indefinitely (boundary layer model), then the geoid offset will remain constant across the width of the transition zone from one side of the fracture zone to the other. If the geoid offset is to both heat transfer across the fault and an increase in the average depth of compensation, it, however, the lithosphere eventually approaches a constant thickness (plate model), the geoid offset will decrease with distance from the fracture zone. An analysis of eighteen GEOD altimetry profiles across the Hinducochin fracture zone (offset 25-30 m.y.) indicates that the geoid amplitude systematically decreases from one side of the fracture zone to the other. The fracture zone seems to behave as a single continuous (older) part of the fault. Although the geoid offsets across the older portion of the fracture zone seem to show one meter across the transition zone, this large decrease in geoid offset strongly suggests that the lithosphere is not a constant thickness along the entire part of the fracture zone. A plate thickness of 100 km fits the observed change in geoid offset along the Hinducochin, but the age differences in the offset determination, the age of the fracture zone, and the age of the plate and the age of the fracture zone, this probably represents a minimum estimate of total plate thickness.

J. Geophys. Res., Vol. 86, Paper 18142

Editorial

AGU Endowment

Exhortations on the need for good communications reach us from numerous and varied sources. But the need is particularly important in the dynamic fields spanned by the AGU. There are a few individuals who thrive on reinventing the wheel. But most of us, although we might enjoy such activity, would as likely play chess, bridge, or engage in some other challenging and recreational activity. Professionally, we need to be aware of the state of the art to be certain we are working on real problems and taking maximum advantage of pertinent advances. And when we have something to report, we want to reach the widest possible audiences. The reasons might be considered selfish by some: our egos, food for our table, etc. But our work cannot impact that of our colleagues if they're not aware of it, and no impact/no promotion.

Agency reports, journals, symposia, and personal contacts all contribute to the dissemination of information. But agency reports usually reach dozens or hundreds of individuals, while AGU journals reach thousands on first distribution, untold numbers after cataloging by abstract services, and are studied in university libraries for decades. AGU-sponsored meetings are primary vehicles for information dissemination through symposia and personal contacts. Clearly, a strong AGU is vital to our effectiveness as scientists.

AGU has been a strong and effective organization over the years and, it is hoped, even without the current fund drive would continue in that role. But it is hoped good enough for us in view of the central role of AGU in our profession? AGU has slim cash reserves to carry it through any of the economic difficulties it might encounter. Even though we do not face imminent or sudden disaster, a short-term difficulty could initiate a feedback loop of increased dues and decreased membership if the dampening effect provided by cash reserves is inadequate. And if I am unduly pessimistic, wouldn't it be great if one day all members received red (or blue or green) JGR free with their dues?

There are many demands on our personal resources, including basic necessities, charitable contributions, and leisure time expenditures. But surely, participation in the AGU fund drive should rank high in priority for scientists in relevant fields in view of the significance of the activities of AGU to their future. And, just as surely, we old timers owe a debt of gratitude for the past impact of AGU on our careers.

R. J. Anderle
President, Geodesy Section

AGU
GIFT

News

Budget Cuts Jeopardize Space Exploration

In the light of 12% across-the-board cuts in the second round of federal budgetary action, the announcement by the Office of Management and Budget that the cut to be absorbed by NASA is only 6% appears to be good news. But this is not at all the case, even though the reduced NASA FY 1982 budget would still be above the FY 1981 budget by about 4%, because the first round of budget cuts trimmed NASA to a bare minimum. The budget had been strained after absorbing the huge first-mission costs of the space shuttle. The portion of the budget for the shuttle still seems to be reserved, untouchable, basically as it was after the first budget-cutting round. Further, the shuttle's costs are rising, and NASA's budget for the following year (FY 1983) is subject to larger cuts—a figure of about \$1 billion has been mentioned.

An idea of the severity of impact on NASA's operations can be had by noting one possible course now being considered: to cancel further operation of the Voyager mission. Voyager has been rolling for over a decade, but future operation costs could be prohibitive. The space sciences community is shocked to think that as Voyager heads toward Uranus and Neptune for the first chance to obtain observations, the tracking stations, the receiving circuits, the highly sophisticated and delicate instrumentation, which have been part of an immensely dedicated effort, might be shut off. The spacecraft would get there, but no data would be obtained.

In summary, the proposed budget cuts could mean the virtual elimination of space exploration and science from NASA's program. Not only Voyager could be lost but the Deep Space Network, the Comet Halley and Galileo missions, and other missions (such as the International Solar Polar Mission) are in jeopardy of being cut. In fact the entire planetary science and applications functions, including the Jet Propulsion Laboratory and other NASA facilities, could disappear. In one possible scenario following the budget cuts, space shuttle and Space Telescope would remain. In describing the impact of the second-round, proposed budget cuts on NASA's programs, *Chemical and Engineering News* (Oct. 5, 1981) stated, "... all ideas for new projects would have to be shelved for some time."

The effects of NASA's budget cuts have already spread to the European space community. *New Scientist* (Oct. 1, 1981, p. 2) describes NASA's current development as 'NASA's high noon'.

The mood at NASA is bleak. The space agency did not grieve when President Reagan, for the 'national good,' cut into its plans for the rest of the decade. But an aura of frustration is unmistakable. Reagan's financial policies have injected an element of uncertainty into the financial equation, and for undertakings that require several years of advance planning, uncertainty is anathema.

The reality of a devastating budget cut that would eliminate NASA's programs of exploration of the solar system is difficult to assess. NASA headquarters is preparing a series of 'last stand' proposals to submit to the White House.—PMB

Quagua Pichincha Volcano

Quagua Pichincha Volcano, north central Ecuador (0.17°S, 78.00°W). All times are local (GMT - 5 hours).

A small phreatic explosion that probably occurred in mid-August deposited fine tephra as much as 1 km southeast of three new vents (3-8 m in diameter) in the summit crater. The new vents formed just east of a lava dome, about 400 m in diameter, emplaced in the center of the summit crater, probably in 1660. Pichincha's horseshoe-shaped summit crater, about 2 km in diameter and 600 m deep, occupies the west end of a 9-km-long massif and is breached to the west, in the opposite direction from Ecuador's capital Quito (population 600,000), which is located at the east foot of the volcano. Aerial observers reported increased fumarolic activity in the summit crater about August 20. Plume heights of as much as several hundred meters were reported in mid-August, and a group that climbed the volcano in early September observed a 200- to 300-m-high plume, but vapor emission had declined to only 2-3 times its normal level by early October. Temperatures of summit crater fumaroles in early October were 88°-90°C, comparable to those recorded in 1976.

Seismographs at Quito and at Cotopaxi volcano (60 km to the south southeast) recorded a series of earthquakes, some of which were large enough to be felt. However, the volcano is in a tectonically active zone, and none of these events was large enough to be detected by the worldwide seismic net. Earthquakes on August 12 at 0804 (probably centered near Quito) and August 21 at 0718 (probably centered about 40 km south of the volcano) had Modified Mercalli intensities of III-IV in Quito. Smaller events recorded on August 25 at 0851 and August 26 at 1311, both apparently centered about 40 km south of the volcano, were not felt, but residents of Quito noticed an event on August 28 at 1822 that probably had a nearby epicenter. Seismographs installed on the north, east, and south flanks of the volcano September 25-27 had recorded no local seismicity (magnitude threshold about 1.5) as of October 7. Dry tilt stations were emplaced beginning 28 September at sites 11.25 km north-northeast, 9 km east, and 7.25 km south-southwest of the central dome.

A UNDRO volcanological team of John Tomblin, Karl Grönvold, and J. C. Sabroux arrived in Ecuador October 1. Chemical analyses of gas samples collected by Sabroux on October 5 will be compared to his analyses of gases collected from the same fumaroles in 1976.

The last major eruption from Quagua Pichincha occurred in 1660, when 40 cm of ash fell on Quito and nuees ardentes flowed down the west flank. Several minor phreatic eruptions were reported in the 19th century, the most recent in 1881.

Information contacts: Minard Hall, Escuela Politécnica, Casilla 2759, Quito, Ecuador; J. C. Sabroux, Centre des Faibles Radioactivités, CNRS, 91190 Gif Sur Yvette, France; National Earthquake Information Service, U.S. Geological Survey, Stop 867, Denver Federal Center, Box 25046, Denver, Colo. 80225.

EOS
TRANSACTIONS, AMERICAN GEOPHYSICAL UNION
The Weekly Newspaper of Geophysics

Send double-spaced manuscripts (four copies) to Eos, AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the above address.

Editors: A. F. Spilhaus, Jr.; **Associate Editors:** Claude J. Allegre, Peter M. Bell, Kevin C. Burke, Arnold L. Gordon, Kristina Katsaros, Gerard Lachapelle, Christopher T. Russell, Richard A. Smith, Sean C. Solomon, Carl Kisslinger; **News Writer:** Barbara T. Richmond; **Editor's Assistant:** Sandra R. Marks; **Eos Production Staff:** Patricia Bangert, Margaret W. Connelley, Eric Garston, James Hebbelthwaite, Dee Sung Kim, Michael Schwartz.

Officers of the Union
J. Tuzo Wilson, President; James A. Van Allen, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

Advertising that meets AGU standards is accepted. Contact Robin E. Little, advertising coordinator, 202-462-6903.

Eos, Transactions, American Geophysical Union (ISSN 0098-3941) is published weekly by the American Geophysical Union from 2000 Florida Avenue, N.W., Washington, D.C. 20009. Subscription available on request. This issue \$5.00. Second-class postage paid at Washington, D.C., and at additional mailing offices.

Copyright 1981 by the American Geophysical Union. Material published in the issue may be photocopied by individual scientists for research or classroom use. Permission is also granted to use short quotes and figures and tables for publication in scientific books and journals. For permission for any other uses, contact AGU Publications Office, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

Views expressed in this publication are those of the authors only and do not reflect official positions of the American Geophysical Union, unless expressly stated.

Cover. (Top) San Francisco's Mission Dolores, which was founded by the Franciscan padres on June 29, 1776, as it appears today. The construction of the present building began in 1782. Adjoining the mission stands the Basilica built in 1816. (Bottom) When San Francisco was still under Spanish rule, Mission Dolores was known as the Mission San Francisco de Asís. (Photos courtesy of San Francisco Convention and Visitors Bureau.)

Petroleum Companies Withdraw From OMDP

The 10 petroleum companies that were to split the costs of the Ocean Margin Drilling Program (OMDP) (*Eos*, February 18, 1980, p. 80) with the National Science Foundation have withdrawn their support from the project. According to Allen M. Shinn, Jr., director of NSF's Office of Scientific Ocean Drilling, the petroleum companies stated that they are not willing to support the fiscal 1982 efforts as planned. Participation at a future date remains uncertain.

The move will indefinitely delay OMDP, Shinn told *Eos*. "I don't think we [NSF] can continue with the program as it is outlined now," he added.

OMDP was to be a joint industry-government venture to explore the geology and, indirectly, the petroleum prospects of the continental slopes and the ocean margins. The joint program, which would have involved much engineering innovation, was promoted by the Carter Administration; in particular, Frank Press, now president of the National Academy of Sciences, worked to achieve acceptance of the government-industry program. Government and industry were to split the first-year costs of \$25 million. It appears that only government funds will be available now.

In August, NSF reorganized its drilling programs (*Eos*, September 1, p. 852), combining the Deep Sea Drilling Project (DSDP) and OMDP. The reorganization, which called for the retirement of the *Glomar Challenger* and the use of the *Glomar Explorer* as NSF's sole drilling ship, also called for a delay in drilling along the ocean margins. Support for the reorganization from the academic community generally was positive, but reaction from industry had been mixed.

The question now is how the program will proceed. The National Science Foundation will have to reformulate its effort; current wisdom within the academic oceanographic community is that withdrawal of the oil companies actually may be beneficial in certain respects. Most likely, the highly successful program that utilized the *Glomar Challenger* will be continued, but the program probably will not proceed with the haste or with the commercial incentives provided by the cooperation of industry. Instead, more emphasis will be placed on basic research, which is perceived as desirable by many sectors of the ocean-floor geology community.—PMB and BTH

American Geophysical Union
European Geophysical Society

are the copublishers of the newest journal serving the earth sciences

TECTONICS

John F. Dewey, editor-in-chief
Paul Tapponnier, European editor
B. Clark Burchfiel, North American editor

TECTONICS Devoted to the best in analytical, synthetic, and integrative tectonics.

AGU \$20. Student \$10.
EQS Members

published bimonthly premiere issue February 1982

For further information or to subscribe, Contact
American Geophysical Union
2000 Florida Ave., N.W.
Washington, D.C. 20009

800-424-2488 (202) 462-6903
Toll Free In the Washington area

Dynamics Explorer Now Operational

The two Dynamics Explorer satellites, launched from the Western Test Range at Vandenberg Air Force Base in California into separate polar orbits, are now fully operational (see EOS, 86, p. 633, August 25). Although the spacecraft did not achieve the planned orbit because of a short burn of the second stage in the Delta launch vehicle, the scientific instruments aboard both satellites are operating. NASA expects that all major scientific objectives of the mission will be achieved.

The lower orbiting DE-2 obtained science data for 12 days after its instruments became operational in late August. Science operations were resumed September 4 after the spacecraft had been repositioned 180° to permit proper instrument cooling. This maneuver must be performed every 6 months, owing to the spacecraft's altitudinal relationship to the sun.

The higher orbiting DE-1 had all instruments activated over the last weekend in August and reeled out 63 of the 100 m (208 of 328 ft) of the long wire antennas on board. The 6-m (19 ft) Astromast booms were also erected.

In the process of activating the antennas and booms, the spacecraft's spin rate dropped from 64 to 9 rpm. Magnetic torquing will be used to increase the spin rate to the desired 16 rpm, scientists said, at which time the wire antennas will be extended.

The satellites are in coplanar orbits and are designed to provide an understanding of the processes by which energy from the sun, in the form of light waves and matter, flows through interplanetary space, enters the region around the earth controlled by the magnetic forces from the earth's magnetic field (magnetosphere), and eventually is deposited in the earth's atmosphere to produce the aurora (northern lights), affect radio transmission, and perhaps influence basic weather patterns. [Source: NASA.]—PMB

Tracking Down Geothermal Waters

Two geochemists say that measuring gas ratios in geothermal waters that have surfaced from deep within the earth can help pinpoint the hottest spot in a geothermal reservoir. The technique avoids inserting long thermometers or drilling deep holes into the earth.

When water falls as rain or flows in rivers and lakes, it picks up from the atmosphere such gases as nitrogen, oxygen, and argon, explain David Norman, assistant geophysics professor at the New Mexico Institute of Mining and Technology, and Carl Bernhardt, a graduate student. As the water sinks into the earth and heats up, most of the atmospheric gases bubble off. Then, the water absorbs other gases such as helium and carbon dioxide from the surrounding rocks and soil. When this hot water rises to the surface by convection, Norman told EOS, it cools rapidly but retains its underground gases. By calculating the ratios of carbon dioxide to methane in the water that has risen to the surface, the temperature of the water when it was deep within the earth can be estimated, the geochemists say. This new method could help tap with precision economic geothermal reservoirs.

Finding a reservoir for exploration is not sufficient, say Norman and Bernhardt, because hot geothermal waters can flow laterally within rock fractures for kilometers before surfacing. Drilling for geothermal waters is expensive; the technique using gas ratios could reduce drilling errors, they say.

Norman and Bernhardt, while working on a broader study of gases related to geothermal waters, found that by measuring several ratios, they could locate precisely the hottest geothermal spot in a given region. Their work was conducted partly in the Lightning Dock area of southwest New Mexico, site of previous geothermal work. The gas ratio technique agrees with previous geothermal exploration

studies on the location of the hottest geothermal spots, they report.

The gas ratios used by the New Mexico team are carbon dioxide to methane, helium to nitrogen, helium to argon, carbon dioxide to nitrogen, and carbon dioxide to argon. The total percentage of carbon dioxide in the gases is also a clue.

Geophysicists

James F. Fitzgerald, Jr., 32, was awarded posthumously his doctoral degree at the University of Idaho commencement earlier this year. He joined AGU in 1969 as a student member of the Volcanology, Geochemistry, and Petrology section. He was killed in the May 18, 1980, eruption of Mount St. Helens.

David W. Stearns has been appointed interim dean of the University of Oklahoma's new College of Geosciences, a major component of the university's proposed \$30 million Energy Center. Before becoming the university's first non-profit professor of energy resources in September 1980, Stearns was professor of geology at Texas A&M's Center for Tectonophysics.

Murray B. McPherson, 61, died on August 20. A member of the Hydrology section, he joined AGU in 1975. He was a former chairman of the AGU Committee on Urban Hydrology.

Charles Gill Morgan, 74, died on August 8, 1980. He joined AGU in 1946 as a member of the Seismology section.

James A. Peoples, Jr., 70, a former AGU Fellow, died on December 12, 1980. He was editor of the *Journal of Geophysical Research* from January 1959 until December 1980. He joined AGU in 1939.

The book (266 pages) consists of tables of minerals arranged, following Larsen and Berman's example, in order of increasing index of refraction (n_x , n_y , or n_z) for use as determinative tools in the laboratory. These span two pages for each mineral entry and convey considerably more diagnostic information than Larsen and Berman. Most helpful, especially for obscure minerals, is that each entry makes an abbreviated reference to an extended work where you can learn more about the mineral.

As with any publication, there are flaws, but, in my opinion, none are fatal. The section on amphiboles, for example, continues the use of species names like barkeville and ferrohastingsite that, though well entrenched, have now been decanonized by the IMA Commission on Mineral Names. Such slips and a truly minimal number of technical errors do not detract from the overall positive impression this book makes. There is room for improvement, perhaps by the addition of a short introductory chapter on the optical conventions to be followed (angles like XAc , for example, are given negative values if they are measured in the obtuse angle between crystallographic axes). This information is to be found in their earlier book, *Mineral Optics: Principles and Techniques*, but could profitably be recast here in the interest of providing a single comprehensive reference.

Finally, though it seems trite in a review these days, the price could be cut by about 50%. At \$39.95, this book makes an excellent desk reference, but I cannot recommend requiring it as a textbook, and I'm certainly not going to be nonchalant about the inevitable immersion oil stains on my personal copy. I will use it, though, and I recommend it to any serious student of optical mineralogy.

Sтивен M. Richardson, Department of Earth Sciences, Iowa State University, Ames, Iowa.

Optical Mineralogy: The Nonopaque Minerals

W. R. Phillips and D. T. Griffen, W. H. Freeman, San Francisco, Calif., xi + 677 pp., 1980, \$39.95.

Reviewed by Steven M. Richardson

Perhaps the most heavily used contribution that Esper Larsen or Harry Berman made to the field of mineralogy was their volume entitled *The Microscopic Determination of the Nonopaque Minerals*, published in 1934 as USGS Bulletin 848. My own copy, now dog-eared and stained with immersion oils, has long since justified the dollar I paid for it 15 years ago. Unfortunately, the Larsen and Berman tables are now out of print and unobtainable by budding mineralogists. So, I might add, is the other standard work of the era, Winchell's *Elements of Optical Mineralogy, II: Descriptions of Minerals*. In this conspicuous gap, Phillips and Griffen have created a new book that they hope will become the logical successor to both of these classic volumes.

Their book is written in two sections. The first (398 pages long) contains detailed discussions of the common non-opaque rock-forming minerals, plus pyrite, magnetite, and rutile, which, though opaque, were apparently too common to ignore. These are arranged according to the order of the Dana system, and each is neatly organized around a standard format that includes Composition and Structure, Physical Properties, Color and Pleochroism, Form, Cleavage, Birefringence, Twinning, Interference Figure, Optical Orientation, Distinguishing Features, and Occurrence. Most valuable for the average user are the excellent crystal drawings, sections, and (for some minerals) stereographic projections that accompany each description. Though a little busy on occasion, these drawings are clearer than many in Deer, Howie, and Zussman. Several of the descriptions are also accompanied by black and white photographs showing the minerals in representative thin sections. For major mineral groups (e.g., pyroxenes, amphiboles, clays, feldspars), the authors also provide comprehensive tables of physical and optical properties. The second section of

AVAILABLE IN ENGLISH

M.I. Budyko's Climatic Changes

... deals with the principal features of modern climate and climates of the past. Budyko uses the semiempirical theory of the atmosphere's thermal regime to quantitatively explain modern climatic changes as well as discuss the development of the Quaternary glaciation.

Published by AGU. Orders under \$50.00 must be prepaid.

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There are no discounts or commissions on classified ads. Any type of ad that is not publisher's choice is not charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in writing on Monday 1 week prior to the date of the issue required.

Replies to ads with box numbers should be addressed to: Box _____, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, DC 20008.

POSITIONS WANTED
Rates per line
1-5 times—\$1.00, 6-11 times—\$0.75, 12-25 times—\$0.55

POSITIONS AVAILABLE
Rates per line
1-5 times—\$2.00, 6-11 times—\$1.60, 12-25 times—\$1.40

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS
Rates per line
1-5 times—\$2.50, 6-11 times—\$1.95, 12-25 times—\$1.75

STUDENT OPPORTUNITIES
For special rates, query Robin Little, 800-424-2488.

POSITIONS AVAILABLE

Physical/Cosmic Oceanographer. The Center for Coastal Studies, Scripps Institution of Oceanography, has an opening for a physical, coastal oceanographer to conduct research in an ongoing program of innovative sediment management technology with emphasis on sediment response to the forcing functions of waves, winds and currents. The incumbent will select and publish on research projects into fundamental physics of coastal and harbor sedimentation and advance estimates to current coastal engineering practices. Appointments are for 1 or 2 years (renewable) at the postgraduate research or assistant research level. Qualifications for postgraduate research level are PhD or equivalent in physical oceanography/coastal processes and/or applied physics/mechanics with emphasis on granular/fluid mechanics. Appointment at the assistant research level requires a M.S. degree and a demonstrated publication record. Salary from \$18,138 to \$25,200 commensurate with qualifications. Submit letter of interest including resume and at least three names of references before 1 December 1981 to: Dr. D. L. Inman, Director, Center for Coastal Studies, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California, 92037. Request position profiles at the same address.

An equal opportunity/affirmative action employer.

Staff Scientists/Scientific Programmers. Research & Data Systems, Inc. has openings available for Staff Scientists and Scientific Programmers to work in areas involved in the processing and application of data from satellite based remote sensing systems. Particular needs involve the study of atmospheric dynamics specifically as it relates to the atmosphere-ocean interface, atmospheric composition and dynamics and dynamic feedback mechanisms. Other needs exist in the area of eddy/mixing computation, objective analysis and radiative transfer. Successful candidates will have an advanced degree in meteorology, physics, astronomy or mathematics with a strong computer software background particularly on IBM equipment. Send resume in confidence to: Research & Data Systems, Inc., 9420 Annapolis Road, Lanham, Maryland 20706. Telephone: (301) 458-0001.

An equal opportunity/affirmative action employer.

Director Geologic Survey, NOAA. The National Oceanic and Atmospheric Administration (NOAA) announces a Senior Executive Service vacancy for the position of Director, Geologic Research and Development Laboratory (GRDL) in the National Geologic Survey, a component of the National Ocean Survey. The duty location is Rockville, Maryland. The salary range is \$47,868-\$50,125 per annum. Duties include providing technical and administrative supervision over employees and activities of GRDL; advising officials on the state of scientific knowledge in geology and making recommendations for research and development; exercising scientific and technical knowledge of contribution to publications to professional journals and making presentations at national and international meetings; and advising and consulting scientists and executives in improvement of geologic and related fields. Experience in management of scientific programs, geology, and solid earth sciences is required. Apply to: NOAA/NOS-6001 Executive Boulevard, Rockville, Maryland 20862. Attn: MB/PER/STN

NOAA is an equal opportunity employer.

Visitor Appointments: NCAR. Visitor Appointments at the High Altitude Observatory are available for new and established Ph.D.'s for up to one year periods to carry out research in solar physics, solar-terrestrial physics, and related subjects. Applicant should provide a curriculum vitae including education, work experience, publications, the names of three scientists familiar with their work, and a statement of their research plans. Applications must be received by 15 January 1982, and should be sent to: Visitor Committee, High Altitude Observatory, National Center for Atmospheric Research (NCAR), P.O. Box 3000, Boulder, Colorado 80507. NCAR is an equal opportunity/affirmative action employer.

University of Hawaii Faculty Positions. The Department of Geology and Geophysics and the Hawaii Institute of Geophysics of the University of Hawaii are seeking applicants for two tenure track positions becoming available January 1, 1982. Applicants should have specialization in (1) marine geology with emphasis in one or more of the fields: marine sedimentology, magnetism and gravity; or (2) marine geophysics/seismology. One of these positions will be filled at a rank of full professor, the other at assistant or associate level.

Applicants should have demonstrated ability to conduct and supervise marine research commensurate with the level of the application. Ability to teach at all levels is expected. The positions will be joint ones on an 11-month basis with the Department of Geology and Geophysics and the Hawaii Institute of Geophysics. Applicants will be interviewed at the University of Hawaii. Send resume and names of three references to: Department of Geology and Geophysics, University of Hawaii, Honolulu, HI 96822. Closing date for applications is January 1, 1982. The University of Hawaii is an affirmative action equal opportunity employer.

University of Tennessee, Knoxville/Faculty Positions. The Department of Geological Sciences (Main Campus of the UT System) invites applications for two or three tenure track teaching/research positions effective September 1, 1982. The appointments will be at the assistant or associate professor level in:

1. Sedimentology or Low-Temperature Geochemistry
2. Metamorphic Petrology or Mineralogy
The Ph.D. is required. Duties will include pursuit of an active research program as well as teaching and advising at graduate and undergraduate levels. Preference will be given to those with demonstrated teaching capabilities. Applicants will be interviewed at the Cincinnati G.S.A. meeting, Send resume (including transcripts) and names of three references to: Thomas W. Brodhead, Search Committee, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37916. Application deadline, January 15, 1982. The University of Tennessee is an EEO/Section 504 employer.

Research Position in Chemical Oceanography. California Institute of Technology, Division of Geological and Planetary Sciences. The position of research fellow is being offered at Caltech for research in oceanography. Investigation of the isotopic composition of neodymium and rare earth abundances in sea water and sediments is now being carried forward. The mechanism of injection of REE into sea water will be studied. The differences in $^{143}\text{Nd}/^{147}\text{Nd}$ in various water masses (Piegars et al., Earth and Planet. Sci. Lett. 46, 223-236 and Piegars and Wasserburg, Earth and Planet. Sci. Lett. 52, 128-138 (1980)) is now being carried forward as an exploratory venture in order to determine the origin and chemical behavior of REE in the ocean and the potential use of $^{143}\text{Nd}/^{147}\text{Nd}$ as a tracer. The laboratory facilities for sample preparation and analysis are fully functional and will be available. Applicants should have training in oceanography and a good perspective on general physical oceanographic models.

Send resume and references to Professor G. J. Wasserburg, Lunaril Astrochem, California Institute of Technology, Pasadena, CA 91125. Caltech is an equal opportunity/affirmative action employer (M/F/H).

Petrologist Northern Illinois University. Applications are invited for a tenure track position in igneous or metamorphic petrology at the assistant or associate professor level beginning either January, 1982 or August, 1982. A Ph.D. degree is required and post-doctoral research experience is preferred. The successful candidate will be expected to pursue an active research program, teach at the undergraduate and graduate level, and direct Masters and Ph.D. graduate research work. Facilities housed within the Department of Geology include a fully automated electron microprobe, SEM, solid-source and gas-source mass spectrometers, AA, XRD, and XRF. To receive full consideration, please send resume, statement of research interests, and the names of three references, by November 1, 1981, to Jonathan H. Berg, Search Committee Chairman, Department of Geology, Northern Illinois University, DeKalb, Illinois, 60115. An equal opportunity/affirmative action employer.

Seismologist. Applications are invited for a postgraduate research position in seismology at the Scripps Institution of Oceanography. Applicants specializing in all areas of seismology will be considered, although preference will be given to recent graduates interested in seismic wave propagation, particularly as applied to the oceanic environment and digital signal processing. The position has a duration of one year, with the possibility of extension to two years, and an annual stipend of \$18,800. Please send resume and three references to either Dr. Thomas H. Jordan or Dr. John Orcutt, A-015, Geological Research Division, Scripps Institution of Oceanography, La Jolla, CA 92037, prior to 1 December 1981. Scripps Institution of Oceanography, University of California, San Diego is an affirmative action/equal opportunity employer.

Faculty Positions. Arizona State University, Department of Geology. Applications are invited for two tenure-track faculty positions, one at the assistant professor level and one at the associate level, beginning in August of 1982. One of these positions requires a candidate with interests in applying modern solid state science to geological phenomena. The selected candidate should develop an active research program and may use the extensive facilities offered by the Facility for High Resolution Electron Microscopy at ASU. Teaching duties will include undergraduate mineralogy. Candidates for the other position should complement and extend existing strengths in the department. Possible areas include low temperature geochemistry, heavy isotope geochemistry, soil and earth geophysics, tectonophysics, and related fields. The ability to use modern techniques in both field and laboratory studies and to integrate diverse approaches is highly desirable. Please send a detailed statement of research and teaching interests and a resume with names of four references to David Kinney, Department of Geology, Arizona State University, Tempe, AZ 85287, by January 15, 1982. Arizona State University is an equal opportunity/affirmative action employer.

Visitor Appointments: NCAR. Visitor Appointments at the High Altitude Observatory are available for new and established Ph.D.'s for up to one year periods to carry out research in solar physics, solar-terrestrial physics, and related subjects. Applicant should provide a curriculum vitae including education, work experience, publications, the names of three scientists familiar with their work, and a statement of their research plans. Applications must be received by 15 January 1982, and should be sent to: Visitor Committee, High Altitude Observatory, National Center for Atmospheric Research (NCAR), P.O. Box 3000, Boulder, Colorado 80507. NCAR is an equal opportunity/affirmative action employer.

University of Hawaii Faculty Positions. The Department of Geology and Geophysics and the Hawaii Institute of Geophysics of the University of Hawaii are seeking applicants for two tenure track positions becoming available January 1, 1982. Applicants should have specialization in (1) marine geology with emphasis in one or more of the fields: marine sedimentology, magnetism and gravity; or (2) marine geophysics/seismology. One of these positions will be filled at a rank of full professor, the other at assistant or associate level.

Applicants should have demonstrated ability to conduct and supervise marine research commensurate with the level of the application. Ability to teach at all levels is expected. The positions will be joint ones on an 11-month basis with the Department of Geology and Geophysics and the Hawaii Institute of Geophysics. Applicants will be interviewed at the University of Hawaii. Send resume and names of three references to: Department of Geology and Geophysics, University of Hawaii, Honolulu, HI 96822. Closing date for applications is January 1, 1982. The University of Hawaii is an affirmative action equal opportunity employer.



Centro de Investigación y Desarrollo de
Petróleos de Venezuela S.A.

INTEVEP, S.A.

INTEVEP, S.A. is the Research and Development Center of Petróleos de Venezuela, S.A.. The Center carries out applied research in the areas of petroleum exploration, production, refining and petrochemicals.

Immediate openings exist in Caracas, Venezuela for experienced geologists, geophysicists and engineers specializing in rock mechanics. Candidates should have a Master's and/or PhD degree. Bilingual (English/Spanish) candidates preferred. Primary responsibility will be the setting up of a laboratory to study the behavior of rocks and/or unconsolidated sands that contain oil.

Please submit a resume to the address below no later than December 31, 1981.



INTEVEP S.A.
750 Welch Road, Suite 204
Palo Alto, CA 94304

Petrologist-Economic Mineralogist-University of Oklahoma. Applications are invited for a tenure-track position, effective September 1, 1982 at the assistant professor level, in petrology and economic mineralogy. The successful applicant is expected to teach graduate courses in his/her specialty, to help teach undergraduate courses in petrology, and to pursue an active research program. Consulting and interacting with mining companies are encouraged.

The University of Oklahoma has made a major commitment to diversify the program in the School of Geology & Geophysics. As a result five tenure-track positions are open for the fall of 1982. Six new faculty were added to the School in the fall of 1981 bringing the total full-time faculty to 151, and an additional six positions will be available during 1983-1985. A new building that will house the School is in the design stage, and the successful applicant will participate in equipping it.

The Ph.D. degree is required for this position. Preference will be given to petrologists with a demonstrated chemistry background and with a demonstrated interest in the economic geology of metallic and non-metallic mineral deposits. Qualified applicants should arrange to send transcripts of all college and university work, resume, statement of research interests, and three letters of reference to: Dr. Maryellen Cameron, School of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma 73019. Deadline for applications is December 31, 1981. Faculty members from the School will be interviewing at the November G.S.A. meeting in Cincinnati, Ohio, and at the December A.G.U. meeting in San Francisco, California. The University of Oklahoma does not discriminate on the basis of race, sex, or age, and is an equal opportunity employer.

EARTH SCIENCES

The Lamont-Doherty Geological Observatory of Columbia University invites scientists interested in any field of the earth sciences to apply for the following fellowships: two postdoctoral fellowships, each awarded for a period of one year (extendable to two years in special instances) beginning in September 1982 with a stipend of \$22,500 per annum. Completed applications are to be returned by January 15, 1982. Application forms may be obtained by writing to the Director, Lamont-Doherty Geological Observatory, Palisades, New York 10964. Award announcements will be made February 28, 1982 or shortly thereafter. The Observatory also welcomes applications from candidates for postdoctoral research associate positions in this discipline.

University of Leeds-Isotope Geologist. Applications are invited for a postdoctoral RESEARCH FELLOW in the Department of Earth Sciences for a fixed term of up to two years. The research programme of the Isotope Geology Group in the Department includes geochronology oriented particularly towards evolution of metamorphic belts, and applications of radiogenic isotope geochemistry to petrogenetic problems and the present state and past history of the earth's mantle. Equipment available includes two solid-source mass spectrometers (Micromass 30 and Isomass 54) for Sm-Nd, U-Pb, Rb-Sr and REE determinations and two MS10's for K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ with supporting chemical facilities which are dedicated to these programs and to projects in oceanic isotope geochemistry. The successful applicant will be expected to initiate work in one or more of these fields and to collaborate in appropriate current projects. Salary within the range £6070-£10160 according to age, qualifications and experience. Informal enquiries may be made to Professor J. C. Briden. Further particulars and application forms (if desired) may be obtained from the Registrar, The University, Leeds LS2 9JT, UK, quoting reference number 4620/HG. Closing date for applications 30 November 1981.

Quaternary Sedimentation and Tectonics or Geophysics. The Geology Department at Miami University invites applicants for a position in either the field of Quaternary sedimentation (including glacial deposits) and tectonics or the field of geophysics. This position is to be filled at the Assistant Professor level beginning in August, 1982. The successful candidate will teach both undergraduate and graduate courses, must possess the Ph.D. degree and have documented ongoing research to be considered for the tenure track position.

Quaternary Sedimentation and Tectonics. Ideally applicants should have research and teaching interests in: (1) basin development and recent tectonics; (2) Quaternary sediment transport and depositional processes including till deposition; and (3) geomorphology. Applicants should have research and teaching interests in: (1) relations between crustal structure and basin and continental margin evolution; or (2) general geophysics to include areas from among seismology, geomagnetism, gravity, electrical or heat-flow studies. Visiting Assistant Professorship in Geology. The Department also invites applicants for a visiting assistant professor position beginning in August 1982. This position is to be filled at the Assistant Professor level beginning in August, 1982. The successful candidate will teach both undergraduate and graduate courses, must possess the Ph.D. degree and have documented ongoing research to be considered for the tenure track position.

Quaternary Sedimentation and Tectonics. Ideally applicants should have research and teaching interests in: (1) basin development and recent tectonics; (2) Quaternary sediment transport and depositional processes including till deposition; and (3) geomorphology. Applicants should have research and teaching interests in: (1) relations between crustal structure and basin and continental margin evolution; or (2) general geophysics to include areas from among seismology, geomagnetism, gravity, electrical or heat-flow studies. Visiting Assistant Professorship in Geology. The Department also invites applicants for a visiting assistant professor position beginning in August 1982. This position is to be filled at the Assistant Professor level beginning in August, 1982. The successful candidate will teach both undergraduate and graduate courses, must possess the Ph.D. degree and have documented ongoing research to be considered for the tenure track position.

Applicants should send a resume, transcripts, three (3) letters of reference and an outline of teaching and research interests to: Dr. A. Dwight Baldwin, Jr., Chair, Geology Department, Miami University, Oxford, Ohio 45056. An equal opportunity/affirmative action employer.

The Caswell Silver Distinguished Professorship in Geology THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico is pleased to invite nominations or applications for the Caswell Silver Distinguished Professorship in Geology. This endowed professorship shall be awarded for periods of up to two years to earth scientists of distinguished accomplishment and international reputation. The professorship may be held by scientists of all specialties of the earth sciences in the broadest sense, and the major criterion for selection is that the individual be an active, productive leader in his or her field of research. The recipient must carry out a vigorous research program while in residence at UNM. The recipient is expected to interact with the faculty and students of the Department and to provide one or more seminars. In an advanced topic of his/her choice, during each academic year. The Foundation will provide unusually advantageous remuneration commensurate with the distinguished nature of the appointment. In addition, a generous allocation for travel and operating expenses to include secretarial support, analytical services in department laboratories, use of field vehicles, and preparation of manuscript(s) will be provided.

Applications or nominations should include a detailed resume and brief statement of major research accomplishments. Applications or nominations should be forwarded to:

Rodney C. Ewing, Chairman
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131



The deadline for applications is January 1, 1982.
The Caswell Silver Foundation is an equal opportunity employer.

University of Maryland/Faculty Positions. The University of Maryland invites applications from highly qualified candidates for a tenure track faculty position at the assistant or associate professor level in the Department of Meteorology. Candidates must have a Ph.D. in meteorology, physics, engineering or chemistry and have an area of specialization that will enable them to lead a research program in environmental physics and air pollution. The research activity of the candidate should complement the meteorological research of the Department and continue the strong interaction in the physical sciences across departmental lines. Duties will include teaching senior graduate courses related to environmental physics and air pollution and developing an active research program. Salary will be commensurate with qualifications and experience. All applicants should send curriculum vitae, a brief statement of research interests and names, addresses and telephone numbers of those professional references to: Professor Ferdinand Baer, Chairman, Department of Meteorology, University of Maryland, College Park, MD 20742. Closing date for applications is 1 December 1981.

The University of Maryland is an equal opportunity affirmative action employer.

Position in Reflection Seismology/Rice University, Houston, Texas. The Department of Geology plans to expand its geophysical program. Emphasis will be on reflection seismology. At this time applications are for the first of two open faculty positions. The successful applicant will help in the search for and selection of the second faculty member.

Your main responsibility will be to lead our department into the area of modern reflection seismology. Your main teaching and research interests should be in the acquisition and processing of reflection seismic data. You should also help in developing new undergraduate and graduate curricula, which are supported by the traditional strength of the Math Sciences, Physics, and Electrical Engineering Departments at Rice. Enthusiasm to work with and undertake some joint projects with our geologists is essential.

Our plans are to acquire a computer system configured for high quality data processing. Substantial seed money for this facility is already in hand. Creative cooperation with the oil and geophysical industry in Houston, including a reasonable amount of consulting, is encouraged. Salary will be commensurate with qualifications and experience.

Please send your curriculum vitae, a summary of experience in seismic processing, a statement of research interests, and names of three or more references to: Dr. A. W. Bally, Chairman, Department of Geology, Rice University, P.O. Box 1892, Houston, Texas 77001. Application deadline—December 1, 1981.

Rice is an equal opportunity employer.

Stanford University. A postdoctoral or research associate appointment is available in the area of space plasma physics. Topics of study include data from electron beam experiments aboard the space shuttle and the behavior of low energy plasma in the magnetosphere. Resumes and names of three references should be sent to Professor P. M. Banks, Radio Science Laboratory, Department of Electrical Engineering, Stanford University, Stanford, CA 94305.

Stanford University is an equal opportunity employer.

Instrumental Analysis/Staff Research Associate III. Job # 81-08-23. Oversee computerized automated wave-length dispersive XRF spectrometer. Minimum qualifications: one year analytical experience or equivalent academic background, preferably but not necessarily with XRF or NOVA computer. Duties include: maintenance and repair of equipment; software development in FORTRAN for on-line microcomputer; participation in design and execution of strategies for analyzing trace metals in geological materials; and instruction of users. After first year, opportunity exists for personal research as time permits. Applicants should list equipment and applications with which they've experienced, and responsibilities therewith. Salary \$1765/month.

Apply to Personnel Office, University of California Santa Cruz, 1168 High Street, Santa Cruz, CA 95064 no later than November 1, 1981.

Field Research Positions. The Exploration Research Laboratory of the Colorado School of Mines may have openings for a field party manager and/or an assistant field party manager on or about January 1, 1982. Position level will be negotiated based on qualifications. This position involves, principally, seismic data acquisition but the person may participate in a wide range of field activities including geology, geophysics, and geodesy, etc. This is an opportunity to participate with a large geophysical research and development group. Specific responsibilities include planning and coordination of field work, training of crew members, and supervision of pre-processing. The position is most challenging and offers wide scope for initiation and acceptance of responsibility. Interaction with industry professionals, ERI staff, and faculty members of the Department of Geophysics is required. It is a position for growth, and challenge. A bachelor or masters degree is required for each of the positions. Field crew experience would be helpful. Ability to direct subordinates, interface with diverse groups, and communicate results is essential. Extensive field time is required for the Assistant Field Manager. Significant field time is required for the Manager. Schedules are not firm and are subject to research commitments and research time frames. Typical academic environment fringe benefits are available. If interested in further details or in submitting an application, contact Dr. James K. Applegate, Director, Exploration Research Laboratory, Colorado School of Mines, Golden, Colorado 80401.

The Colorado School of Mines is an affirmative action/equal opportunity employer.

Groundwater Hydrologist. The Minnesota Department of Natural Resources, Division of Waters has a vacancy at the Principal Hydrologist level for an experienced groundwater hydrologist to provide leadership for a program of ground water studies and monitoring to support State Water allocation decisions and to provide quantitative assessments for planning and management purposes.

Address inquiries and requests for application forms to: Sarah P. Telford, DNR-Division of Waters, Third Floor Space Center Building, 444 Lafayette Road, St. Paul, Minnesota, 55101. Present salary range: \$23,323 to \$31,132 annually, subject to revision in the near future.

University of South Florida. 3 New Faculty positions in the Department of Marine Science: The Department of Marine Science at the University of South Florida, St. Petersburg, announces the establishment of three new faculty positions beginning in September 1982. Applications from persons in the following specialties are especially encouraged:

Microbial ecology, marine ichthyology, carbonates, paleontology/stable isotope paleoclimatology, and physical oceanography.

University of California, Davis: Ignouso Petrologist. The Department of Geology invites applications for a tenure-track position in the field of igneous petrology, at the Assistant Professor level, effective for the academic year 1982-1983. Preference will be given to candidates whose research demonstrates a thorough understanding of field, theoretical and experimental approaches to the science and who show promise for high caliber research on fundamental problems. The successful candidate will be expected to contribute effectively to the existing teaching program in igneous petrology at both the undergraduate and graduate levels.

Departmental facilities include a thin-section laboratory and electron microscope, both of which are supported by full-time personnel, an experimental laboratory with high pressure piston cylinder and low pressure externally heated equipment, a scanning electron microscope, stable isotope laboratory, as well as the usual equipment (XRF, XRD, computers, etc.). The University of California at Davis is located conveniently to areas containing all types of igneous rocks.

The final date for receipt of applications is February 1, 1982. The University of California is an equal opportunity affirmative action employer.

Interested individuals should send their resume to:

Jane H. Lipps, Chair
Department of Geology
University of California
Davis, California 95616.

Faculty Positions: The University of Iowa. The Department of Physics and Astronomy anticipates one or two openings for tenure-track faculty in August 1982. One or more visiting professorships, at any rank, are also expected to be available. Preference will be given to candidates with research activity in the following experimental and theoretical areas: astronomy, astrophysics, atomic physics, condensed matter physics, elementary particle physics, nuclear physics, plasma physics, and space physics. The positions involve undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should send a statement of research interests, and the names of three professional references to Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity affirmative action employer.

Geophysical Fluid Dynamics/Physical Oceanographer. Applications are solicited for a junior faculty position in ocean physics or dynamics to begin in the academic year 1982-83. Areas of interest to the Department include analytical, numerical and laboratory modeling of physical processes and phenomena in the ocean.

Yale University is an equal opportunity affirmative action employer and encourages women and members of minority groups to compete for this position. Curriculum vitae, publications, and the names of three or more references should be sent by 31 December 1981 to: Robert B. Gordon, Chairman, Department of Geology and Geophysics, P.O. Box 6666, New Haven, CT 06511.

Faculty Positions: The University of Alabama. Applications are invited for three tenure track positions to be filled by Aug. 16, 1982. Two of the positions are expansion to accommodate a developing Ph.D. program. Applicants would be expected to teach undergraduate and graduate courses and actively pursue research. Ph.D. is required for retention of position. Assistant Professors preferred.

Position 1—Structural Geologist. Positions 2 & 3—two from following interests: Hydrogeology, applied geophysics, low temperature geochemistry, economic geology/ore deposits, coal geology, paleontology, and physical sedimentology. Closing date: Jan. 15, 1982. Send resume, transcripts, and three letters of reference to: Dr. W. Gary Hooks, Acting Chairman, Department of Geology, The University of Alabama, Box 1945, University, AL 35886.

The University of Alabama is an equal opportunity affirmative action employer.

Faculty Positions: Environmental Engineering. Beginning January or September 1982. The position requires undergraduate and graduate teaching and sponsored research activities in the area of water quality control and water resources. An earned doctorate is required and at least one degree in civil engineering is preferred. Rank will be at the assistant professor level and salary will depend upon qualifications. Apply to: Dr. Lester A. Hoel, Chairman, Department of Civil Engineering, University of Virginia, Charlottesville, Virginia 22901.

An affirmative action/equal opportunity employer.

POSTDOCTORAL FELLOWSHIP The Naval Postgraduate School, Monterey, CA.

We are seeking a recent doctoral graduate with an interest in geomagnetics and some background in geophysical instrumentation and computer data analysis. The candidate will be expected to participate in ongoing experimental program of sea floor magnetic measurements using the School's research vessel and remote land based station. Stipend competitive with current practices. For further information, contact Prof. O. Heinz, Dept. of Physics, Naval Postgraduate School, Monterey, CA, 93940, or call (408) 646-2116.

NPS is an equal opportunity affirmative action employer.

Structural Geologist/University of Wyoming. The University of Wyoming, Department of Geology and Geophysics seeks applicants for a tenure track appointment in structural geology expected to be available beginning fall semester 1982 or earlier. Duties will include teaching of undergraduate and graduate courses in structural geology, supervising MS and PhD theses, and research in structural geology. Appointment at assistant professor level is preferred, but applicants requesting appointment at higher rank will be considered. Salary open. Applicants must have PhD degree and be versed in quantitative theory as well as field application or modern structural geology and regional tectonics.

Applicants should provide, by January 1, 1982, a resume, three letters of reference, and a letter of application including a statement of current research interests and courses which the applicant feels qualified to teach. Applications should be sent to:

Dr. Robert S. Houston/Head
Department of Geology and Geophysics
University of Wyoming
Laramie, Wyoming 82071-3006.

The University of Wyoming is an equal opportunity affirmative action employer.

Engineering Geologist/Geophysicist. The Department of Geological Sciences, University of Saskatchewan, has a vacant tenureable position in engineering geology/geophysics. Applicants should be qualified to teach undergraduate and graduate courses and to conduct research in engineering geology. A background in structural geology may be appropriate. Well-equipped facilities are available for research in rock mechanics, fluid flow through porous media, acoustic, and electrical properties of rocks, and permafrost. Good opportunities exist for joint research with qualifications and experience. Send applications, detailed personal resume including the names of at least three references, and other supporting data to: Dr. W.G.E. Caldwell, Head, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0.

Please note: until November 15, 1981 consideration will be given only to applicants who are Canadians or landed immigrants; after that date all applications will be considered.

City University of New York, (Brooklyn College) Faculty Positions. The Department of Geology anticipates filling several tenure track positions at Full Professor level. (Salary range up to \$43,400). Highly qualified individuals will be considered for distinguished appointments at an additional \$5,000.

While candidates who have distinguished themselves in any field are welcome to contact us, we are particularly interested in openings in: energy resources (coal/petroleum), exploration geophysics, environmental geology or hydrogeology, coastal sedimentology, economic geology. Successful applicants will be required to institute an active research program, supervise Master's and Ph.D. theses. Nominations and applications with current vitae should be sent to: Dr. S. Bhattacharya, Chairman, Dept. of Geology, Brooklyn College of City University of New York, Brooklyn, New York 11210. Positions open until filled.

Brooklyn College, CUNY, is an affirmative action/equal opportunity employer.

Geophysics University of Colorado

The Department of Physics, University of Colorado at Boulder, and the Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado/NOAA are currently recruiting for a tenure track faculty member, in the Department of Physics, with simultaneous appointment as a Fellow of CIRES, who will complement the Department's active role in the University's Interdepartmental Graduate Program in Geophysics. We are particularly (but not exclusively) seeking persons with experience and interest in the areas of space geodesy, geodynamics, or related areas of theoretical geophysics.

Appointment will be at the level of assistant professor (minimum salary: \$20,000 per academic year) and is expected to start in the fall of 1982. The appointment entails full participation in the Department's undergraduate and graduate teaching programs (including offerings in the appointee's specialty), supervision of graduate students in appropriate areas, and the development of an active research program.

Candidates should send a letter of interest, a current curriculum vitae, and have three letters of reference sent no later than 1 January 1982 to:

Chairman
Department of Physics
Campus Box 390
University of Colorado
Boulder, Colorado 80309.

The University of Colorado is an affirmative action/equal opportunity employer.

Virginia Polytechnic Institute and State University Senior Research Associate. Involvement and abundant research and publishing opportunities. Including new University-owned MDS-10 VEROSIS system, VAX 11/780 computer. Must have experience in theory and application of reflection seismology, and be interested in the application of reflection seismology to the solution of geologic problems.

Send resumes to: Dr. D. R. Wones, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0706.

The University is an equal opportunity affirmative action employer.

Yale University/Department of Geology and Geophysics. Applications are solicited for a faculty position in solid earth geophysics to begin in the academic year 1982-83. Areas of interest to the Department include seismology, exploration geophysics, mechanical and physical properties of rocks and minerals, geomagnetism, and tectonophysics.

Yale University is an equal opportunity affirmative action employer and encourages women and members of minority groups to compete for this position. Curriculum vitae, publications, and the names of three or more references should be sent by 31 December 1981 to Robert B. Gordon, Chairman, Department of Geology and Geophysics, P.O. Box 6666, New Haven, CT 06511.

Assistant Professorships/University of Virginia. The Department of Environmental Science, University of Virginia invites applications for two tenure track assistant professorships beginning September 1982:

—Climatology/meteorology
—Environmental chemistry/geochemistry
—Water resources/hydrology

Applicants should have a Ph.D. and expect to teach undergraduate and graduate level courses in one area of specialization and to pursue a vigorous research program within the context of an interdisciplinary department. A curriculum vitae, a brief statement of research interests and names of three referees who may be contacted for references, should be sent to: George M. Hornberger, Department of Environmental Sciences, Clark Hall, University of Virginia, Charlottesville, Virginia 22903.

The University of Virginia is an equal opportunity affirmative action employer.

Purdue University. The Department of Geosciences invites applications for a faculty position, starting January or July 1982, in the broad field of geology-petrology-geochemistry. A Ph.D. is required and preference may be given to scientists with an established record of research. The Department has an automated X-ray diffractometer, mass spectrometer and laboratory for stable isotope studies, all range of high temperature and high pressure equipment, including furnaces for controlled experiments, as well as X-ray equipment. The successful applicant will be expected to participate with the undergraduate teaching and graduate research programs, as well as actively engage in research. Rank and salary are open but will be commensurate with qualifications.

Seismologist/University of Utah. Search extended: The University of Utah is expanding its geophysics program in the Department of Geology and Geophysics by adding a tenure track faculty member in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic reflection, seismic imaging, and theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses, and to pursue an active research program with graduate students. The department has modern teaching and research programs in geology and geophysics, and has close associations with the numerical analyses and data processing groups in computer science, electrical

Purdue University is a land grant, state supported institution committed to academic excellence, and is an equal opportunity affirmative action employer. For further information please contact Dr. Henry O. A. Meyer, Dept. of Geosciences, Purdue University, West Lafayette, IN 47907 (Tel. 317-494-3271). Closing date for applications is November 10, 1981.

Supervisory Physical Scientist. The Research Facilities Center (RFC) of NOAA in Miami, Florida, is seeking a senior level scientist to manage its Research Systems Group. The RFC equips, maintains, and operates aircraft, helicopters and ground based equipment specifically for atmospheric, oceanographic and environmental research. The incumbent will direct a group of scientists, engineers and technicians involved with collection, calibration, quality control, formatting, documenting and delivery of data to users of the RFC. This position is in the Competitive Service. The grade and advance level salary of the position is GS-14, \$37,871 "per annum. Future salary adjustments are subject to the Merit Pay system. QUALIFICATIONS: BS or higher degree in meteorology, physics, math, oceanography, or the physical sciences. In addition, 3 years of professional experience which has equipped the candidate with the knowledge necessary to perform the above duties. SELECTIVE FACTORS: Applicants must have experience in a research and development environment and be capable of directing research in instrumentation physics, calibration techniques, advanced computer techniques and spectral analysis. Additional technical information may be obtained from Dr. C. B. Emmanuel (305) 526-2936 or FTS 350-2936. TO APPLY: Current or former federal employees should submit SF-171 and CD-332 (Employee Appraisal), Form CD-332 may be obtained by calling (305) 361-4454 or FTS 350-1454. Applicants not employed by the Federal Government should submit a complete application package for "Physical Science Position-1300". These forms may be obtained from the nearest Office of Personnel Management (OPM). ALL APPLICANTS MUST SUBMIT THEIR PUBLICATIONS RECORD. All applications should be submitted to: ERL Area Personnel Office, 4301 Rickenbacker Causeway, Miami, Florida 33149. Ref. No. NOAA/ERL 81-232. Applications must be received by November 13, 1981, to receive consideration. AN EQUAL OPPORTUNITY EMPLOYER. Salary subject to increase due to October comparability adjustment.

Earth and Planetary Sciences, Massachusetts Institute of Technology. Our Department has research and teaching assistantships available for new graduate students enrolling in September 1982. Research opportunities encompass a wide range of topics in planetary sciences, geophysics, geology, geochemistry, and petrology. Students with undergraduate majors in geology, physics, chemistry, mathematics and engineering are encouraged to apply. Detailed information can be obtained from Debby Rockner, SA-912A, M.I.T., Cambridge, MA 02139, (617) 253-3380.

Graduate Research Assistantships in Physical Oceanography. Opportunities for graduate study with Research assistantship available for students interested in M.S. or Ph.D. programs. A summer program with stipend is open to college juniors. Write: Douglas Caldwell, School of Oceanography, Oregon State University, Corvallis, OR 97331.

Graduate Teaching & Research Assistantships/University of Houston. Graduate teaching & research assistantships available to qualified persons interested in Space Physics at the University of Houston. Our experimental program features rocket & balloon-borne studies of the ionosphere & magnetosphere-ionosphere coupling. Emphasis has been on active experiments. Most recent being a rocket-balloon campaign at Siple station, Antarctica in December 1980. Future work includes a study of pulsating aurora & participation in Waterhole II, an auroral quenching experiment. The theoretical program is on plasma waves in the solar wind & modeling of phenomena related to current experiments. Assistantships for first year students begin at \$6000 mo along with out of state tuition waivers. Graduate Chairman, Physics Dept., University of Houston Central Campus, Houston TX 77004 HOE.

Associate Professor Office (100-110-12)

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, N.W.

Washington, D.C. 20037

Postmark deadline for applications: January 15.

National Research Council

National Academy of Sciences

National Academy of Engineering

Institute of Medicine

Meetings

AAAS Pacific Division Meeting

A call for papers has been issued for the 63rd Annual Meeting of the American Association for the Advancement of Science, Pacific Division. The meeting will be held June 20-26, 1982, at the University of California at Santa Barbara. The American Meteorological Society and the Atmospheric and Hydrospheric Sciences Section (section W) of AAAS Pacific Division will cosponsor sessions and other programs on coastal meteorology, climatology, oceanography, energy, and environmental pollution.

Abstracts should be sent by March 15, 1982, to John Lay, Program Chairman, Department of Geography, California State University, Hayward, CA 94542 (telephone: 415-881-3193). Requests for special equipment and audiovisual aids should accompany the abstracts.

Abstract format and additional information can be obtained from Alan E. Leviton, Executive Director, AAAS (Pacific Division), California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118 (telephone: 415-752-1554). Nonmembers are encouraged to attend. \$

Coastal Structures

A call for papers has been issued for 'Coastal Structures '83,' a specialty conference on the design, construction, maintenance, and performance of port and coastal structures. The conference is scheduled for March 9-11, 1983, in the Washington, D.C., area.

Prospective authors are invited to submit abstracts of 400 words or less on a subject related to one of the following topics: groins, breakwaters, jetties, seawalls, revetments, submerged pipelines, pile-supported structures, port and marine structures; interaction of coastal structures with waves, currents, and sediment transport; seismic and foundation problems with port and coastal structures; functional and structural design, construction (methods, equipment, and materials), maintenance, and operation of port and coastal structures; and innovative case studies dealing with port and coastal structures.

The conference will focus on coastal rather than deep ocean structures, on technical rather than regulatory, socioeconomic, environmental, or management aspects of coastal structures.

Abstracts, due April 15, 1982, should be sent to J. Richard Weggel, Chairman, Program Committee, Coastal Structures '83, c/o Coastal Engineering Research Center, Kingman Blvd., Fort Belvoir, VA 22080. \$

engineering and mathematics. The geophysics component of the department has strong research and teaching programs in seismology, electrical and electromagnetic methods, thermal properties of the earth, and potential fields. Current research in seismology includes: seismological and earthquake research utilizing a new PDP 11/70 computer with plotter and terminals; monitoring of the intermountain seismic belt by a 55 station telemetered network utilizing a new on-line PDP 11/34 computer. Major experiments in seismic relaxation picking, investigations of seismic propagation from synthetic seismograms, application of inverse theory to seismology, seismic properties of volcanic systems and allied research in tectonophysics. The closing date for applications is December 31, 1981. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

University of Utah is an equal opportunity affirmative action employer.

STUDENT OPPORTUNITIES

Earth and Planetary Sciences, Massachusetts Institute of Technology. Our Department has research and teaching assistantships available for new graduate students enrolling in September 1982. Research opportunities encompass a wide range of topics in planetary sciences, geophysics, geology, geochemistry, and petrology. Students with undergraduate majors in geology, physics, chemistry, mathematics and engineering are encouraged to apply. Detailed information can be obtained from Debby Rockner, SA-912A, M.I.T., Cambridge, MA 02139, (617) 253-3380.

Graduate Research Assistantships in Physical Oceanography. Opportunities for graduate study with Research assistantship available for students interested in M.S. or Ph.D. programs. A summer program with stipend is open to college juniors. Write: Douglas Caldwell, School of Oceanography, Oregon State University, Corvallis, OR 97331.

Graduate Teaching & Research Assistantships/University of Houston. Graduate teaching & research assistantships available to qualified persons interested in Space Physics at the University of Houston. Our experimental program features rocket & balloon-borne studies of the ionosphere & magnetosphere-ionosphere coupling. Emphasis has been on active experiments. Most recent being a rocket-balloon campaign at Siple station, Antarctica in December 1980. Future work includes a study of pulsating aurora & participation in Waterhole II, an auroral quenching experiment. The theoretical program is on plasma waves in the solar wind & modeling of phenomena related to current experiments. Assistantships for first year students begin at \$6000 mo along with out of state tuition waivers. Graduate Chairman, Physics Dept., University of Houston Central Campus, Houston TX 77004 HOE.

Associate Professor Office (100-110-12)

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, N.W.

Washington, D.C. 20037

Postmark deadline for applications: January 15.

National Research Council

National Academy of Sciences

National Academy of Engineering

Institute of Medicine

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

GEOTHERMAL DEPOSITS. If you are interested in planning, designing, exploring, drilling, or digging in connection with any form of energy, you need this complete, up-to-date book about the world's geothermal-energy deposits. Includes production and reserves for areas and wells. Hardcover, 6 x 9 inches, 292 pages. Table of contents, drawings, index, references, 1978. \$54. Talsch Associates, 120 Thunder Road, Sudbury, MA 01776.

Fundamental Concepts in Modeling Fluid Flow & Solute Transport in Porous Media. Short course on Fundamental Concepts in Modeling Fluid Flow and Solute Transport in Porous Media, January 28-29, 1982, Princeton University, Princeton, NJ. Principal Lecturer: George F. Pinder. This course will focus on equation development and numerical modeling for a wide variety of porous media problems. Case studies and hands-on computer exercises will be included. Contact: Dr. George F. Pinder, Dept. of Civil Engineering (code 123), Princeton University, Princeton, NJ 08544. (609) 921-1123.

NRC RESEARCH ASSOCIATESHIP AWARDS

Comprehensive awards to recent doctoral graduates and experienced senior investigators. Areas of interest include: atmospheric and oceanic sciences, earth and planetary sciences, geophysics, geology, geochemistry, and petrology. Students with undergraduate majors in geology, physics, chemistry, mathematics and engineering are encouraged to apply. Detailed information can be obtained from Debby Rockner, SA-912A, M.I.T., Cambridge, MA 02139, (617) 253-3380.

ATMOSPHERIC & EARTH SCIENCES

ENGINEERING - LIFE SCIENCES

PHYSICS - CHEMISTRY

ENVIRONMENTAL SCIENCES

MATHEMATICS & SPACE SCIENCES

Most of the 16 programs are open to non U.S. nationals and most are open to senior investigators as well as recent Ph.D.s.

Application materials with details on research opportunities and laboratory facilities are available.

Associate Professor Office (100-110-12)

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, N.W.

Washington, D.C. 20037

Postmark deadline for applications: January 15.

National Research Council

National Academy of Sciences

National Academy of Engineering

Institute of Medicine

Ocean Sciences: AGU/ASLO Joint Meeting

February 18-19, 1982
San Antonio, Texas
Convenor: W. D. Nowlin, Jr. (AGU) and R. W. Eppley (ASLO)

Abstract Deadline:
November 10, 1981

Special Sessions *Additional special session

Ocean Climate and Biological Productivity Connections

Overview of Large Oceanographic Projects
Biology and Physics of Gulf Stream Rings
Relations Between Biology and Circulation in the Gulf of Mexico

Geological Effects of Ocean Circulation
Anthropogenic Inputs to the Ocean: Diverse Points of View

